

What Is Claimed Is:

- 1 1. A method for automatically computing a derivative of a numerical
2 expression within a digital computer system, comprising:
3 receiving a representation of the numerical expression within the digital
4 computer system, wherein the numerical expression includes one or more
5 independent variables;
6 forming an expression tree for the derivative of the numerical expression
7 with respect to an independent variable, wherein the expression tree makes use of
8 temporary variables to form results of sub-expressions for computing the
9 derivative of the numerical expression; and
10 wherein forming the expression tree involves seeking to introduce only
11 temporary variables and associated sub-expressions as necessary to eliminate
12 repeated common sub-expressions, thereby substantially minimizing the number
13 of temporary variables; and
14 using the expression tree to compute the derivative of the numerical
15 expression during a computation.
- 1 2. The method of claim 1, wherein for each temporary variable in the
2 expression tree, the method forms an expression for a partial derivative of the
3 temporary variable with respect to each independent variable.
- 1 3. The method of claim 2, wherein forming the expression for a given
2 partial derivative involves defining new temporary variables and corresponding
3 sub-expressions and new partial derivatives.

1 4. The method of claim 1, wherein a given sub-expression can
2 include a multinomial that contains more than one binary operation.

1 5. The method of claim 1, further comprising pruning sub-
2 expressions and associated temporary variables that are not used by the
3 computation.

1 6. The method of claim 5, wherein pruning sub-expressions involves:
2 marking all temporary variables used in evaluating the expression tree; and
3 deleting unmarked temporary variables and associated sub-expressions.

1 7. The method of claim 1,
2 wherein the method is performed within a compiler; and
3 wherein the representation of the numerical expression is in the form of an
4 Abstract Syntax Tree (AST).

1 8. The method of claim 1,
2 wherein the method is performed within a pre-compiler;
3 wherein the expression tree is in the form of a source code list; and
4 wherein each temporary variable and associated sub-expression in the
5 expression tree is represented by computer code that sets the temporary variable
6 equal to the associated sub-expression.

1 9. The method of claim 1, wherein the method is performed by code
2 within a code library.

1 10. The method of claim 1,

2 wherein the computation involves interval arithmetic; and
3 wherein the one or more independent variables are interval variables.

1 11. A computer-readable storage medium storing instructions that
2 when executed by a computer cause the computer to perform a method for
3 automatically computing a derivative of a numerical expression within a digital
4 computer system, the method comprising:
5 receiving a representation of the numerical expression within the digital
6 computer system, wherein the numerical expression includes one or more
7 independent variables;
8 forming an expression tree for the derivative of the numerical expression
9 with respect to an independent variable, wherein the expression tree makes use of
10 temporary variables to form results of sub-expressions for computing the
11 derivative of the numerical expression; and
12 wherein forming the expression tree involves seeking to introduce only
13 temporary variables and associated sub-expressions as necessary to eliminate
14 repeated common sub-expressions, thereby substantially minimizing the number
15 of temporary variables; and
16 using the expression tree to compute the derivative of the numerical
17 expression during a computation.

1 12. The computer-readable storage medium of claim 11, wherein for
2 each temporary variable in the expression tree, the method forms an expression
3 for a partial derivative of the temporary variable with respect to each independent
4 variable.

1 13. The computer-readable storage medium of claim 12, wherein
2 forming the expression for a given partial derivative involves defining new
3 temporary variables and corresponding sub-expressions and new partial
4 derivatives.

1 14. The computer-readable storage medium of claim 11, wherein a
2 given sub-expression can include a multinomial that contains more than one
3 binary operation.

1 15. The computer-readable storage medium of claim 11, wherein the
2 method further comprises pruning sub-expressions and associated temporary
3 variables that are not used by the computation.

1 16. The computer-readable storage medium of claim 15, wherein
2 pruning sub-expressions involves:
3 marking all temporary variables used in evaluating the expression tree; and
4 deleting unmarked temporary variables and associated sub-expressions.

1 17. The computer-readable storage medium of claim 11,
2 wherein the method is performed within a compiler; and
3 wherein the representation of the numerical expression is in the form of an
4 Abstract Syntax Tree (AST).

1 18. The computer-readable storage medium of claim 11,
2 wherein the method is performed within a pre-compiler;
3 wherein the expression tree is in the form of a source code list; and

1 wherein each temporary variable and associated sub-expression in the
2 expression tree is represented by computer code that sets the temporary variable
3 equal to the associated sub-expression.

1 19. The computer-readable storage medium of claim 11, wherein the
2 method is performed by code within a code library.

1 20. The computer-readable storage medium of claim 11,
2 wherein the computation involves interval arithmetic; and
3 wherein the one or more independent variables are interval variables.

1 21. An apparatus for automatically computing a derivative of a
2 numerical expression within a digital computer system, comprising:
3 a receiving mechanism that is configured to receive a representation of the
4 numerical expression within the digital computer system, wherein the numerical
5 expression includes one or more independent variables;
6 an expression tree forming mechanism that is configured to form an
7 expression tree for the derivative of the numerical expression with respect to an
8 independent variable, wherein the expression tree makes use of temporary
9 variables to form results of sub-expressions for computing the derivative of the
10 numerical expression; and
11 wherein the expression tree forming mechanism seeks to introduce only
12 temporary variables and associated sub-expressions as necessary to eliminate
13 repeated common sub-expressions, thereby substantially minimizing the number
14 of temporary variables; and
15 an execution mechanism that is configured to use the expression tree to
16 compute the derivative of the numerical expression during a computation.

1 22. The apparatus of claim 21, wherein for each temporary variable in
2 the expression tree, the expression tree forming mechanism is configured to form
3 an expression for a partial derivative of the temporary variable with respect to
4 each independent variable.

1 23. The apparatus of claim 22, wherein in forming the expression for a
2 given partial derivative, the expression tree forming mechanism is configured to
3 define new temporary variables and corresponding sub-expressions and new
4 partial derivatives.

1 24. The apparatus of claim 21, wherein a given sub-expression can
2 include a multinomial that contains more than one binary operation.

1 25. The apparatus of claim 21, further comprising a pruning
2 mechanism that is configured to prune sub-expressions and associated temporary
3 variables that are not used by the computation.

1 26. The apparatus of claim 25, wherein the pruning mechanism is
2 configured to:
3 mark all temporary variables used in evaluating the expression tree; and to
4 delete unmarked temporary variables and associated sub-expressions.

1 27. The apparatus of claim 21,
2 wherein the apparatus resides within a compiler; and
3 wherein the representation of the numerical expression is in the form of an
4 Abstract Syntax Tree (AST).

1 28. The apparatus of claim 21,
2 wherein the apparatus resides within a pre-compiler;
3 wherein the expression tree is in the form of a source code list; and
4 wherein each temporary variable and associated sub-expression in the
5 expression tree is represented by computer code that sets the temporary variable
6 equal to the associated sub-expression.

1 29. The apparatus of claim 21, wherein the apparatus includes code
2 within a code library.

1 30. The apparatus of claim 21,
2 wherein the computation involves interval arithmetic; and
3 wherein the one or more independent variables are interval variables.